

THE ENERGY OBSERVER

*Energy Efficiency Information for the
Facility Manager*

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Electrical Transformers

The Energy Observer summarizes published material on proven energy technologies and practices, and encourages users to exchange experiences with generic energy products and services. This quarterly bulletin also identifies informational sources and energy training for facility managers and staff. **The Energy Observer** is a service of the **Energy Office, Michigan Department of Labor & Economic Growth**.

Many building owners don't realize that lurking behind closed doors in most institutional, commercial and industrial buildings is equipment that uses energy 24 hours a day – electrical transformers.

TRANSFORMER BASICS

Transformers serve an important role in electrical distribution. Because transmitting electricity at low voltages can be very costly, utilities distribute it over long distances using high voltages. The high voltages are incrementally reduced until they reach the end user. These delivery stages are often referred to as Transmission (500,000V to 35,000V), Distribution (25,000V to 2,400V), and Utilization (below 600V). At each stage, a transformer drops the line voltage to the next stage. A transformer does not generate electric power it simply transfers it from one voltage to another.

The transformer works on the principle that energy can be efficiently transferred by magnetic induction from one winding to another winding through a varying magnetic field produced by alternating current.

TRANSFORMER LOSSES

Transformers do not convert 100% of the energy input to usable energy output. The difference between the energy input and the usable energy output is quantified in losses. There are two types of losses: no-load losses and load losses. No-load losses (or core losses) are the amount of power required to magnetize or energize the core of the transformer. Load losses include losses associated with carrying a load such as winding losses, losses due to stray fluxes in the windings and core clamps, and circulating currents in parallel windings. Load losses increase with higher loading of the transformer. Load losses account for the greatest portion of the losses when a transformer is heavily loaded. Transformer loss data is readily available from most manufacturers.

Typically, these losses lower equipment efficiency levels to between 95% and 99%, and the higher the efficiency the lower the losses. As with losses, efficiency is also effected by the percent of load on the transformer. More load results in lower efficiencies.

INSULATION SYSTEM

The insulation system is the maximum internal temperature a transformer can tolerate before it begins to deteriorate, and eventually, to fail. The insulation system classification represents the maximum temperature permitted in the hottest spot in the winding when operated in a 40°C maximum ambient temperature. The hot spot is determined by adding the 40°C ambient, the 150°C max. average winding rise and the 30°C max. hot spot in winding. This results in a 220°C ultimate temperature at the hot spot, and thus most transformers are designed with a 220°C insulation system.



LOW TEMP. RISE & ENERGY EFFICIENT TRANSFORMERS

Low temperature rise (80°C and 115°C) transformers have been available for many years. In fact they were exclusively referred to as energy efficient transformers until just recently. These low

Annual Operating Costs						
Temperature Rise	No loss	25% Load	35% Load	50% Load	75% Load	100% Load
150°C	\$252	\$343	\$434	\$620	\$1,076	\$1,717
115°C	\$294	\$336	\$427	\$564	\$820	\$1,367
80°C	\$350	\$375	\$431	\$512	\$662	\$988
TP-1 150°C	\$161	\$217	\$336	\$522	\$865	\$1,598
<i>Figures based on a 75kVa transformer at \$0.08/kWh. Information from Eaton/Cutler Hammer</i>						

temperature rise transformers provide better efficiencies when a transformer is loaded at 50% or higher than its rated capacity.

In 1996, the National Electrical Manufacturers Association (NEMA) introduced the standard TP-1-1996 Guide for determining energy efficiency for distribution transformers, developed in conjunction with the U.S. Environmental Protection Agency (EPA). The guide sets minimum efficiency levels for distribution transformers at approximately 98%, depending on kVa rating, which is higher than the standard 150°C rise transformers. TP-1 compliant transformers have lower no-load losses than standard transformers and are more energy efficient therefore when lightly loaded.

ENERGY SAVINGS

One way to evaluate which transformer will best suit your

needs, is to evaluate the costs associated with transformer losses. This can be simply calculated by using the formula below:

$$\frac{\text{Cost}}{\text{year}} = (\$/kWh) \left(\frac{1kW}{1000W} \right) (\text{losses}(W)) \left(\frac{8760hrs}{1year} \right)$$

The table above shows the annual operating costs for a sample set of transformers. You can see that when operated at full load, the 80°C rise transformer costs \$729 less to operate than a standard 150°C rise 75kVa transformer. Results will vary by manufacturer.

GLOSSARY OF TERMS

KVA (Kilo Volt Amperes) – the rating or capacity of the transformer.

Core - The iron or steel core provides a controlled path for the magnetic flux generated in the transformer by the current flowing through the windings.

Magnetic Flux - Lines of magnetic force surrounding a magnet or electromagnet.

Winding - Turns of wire around the core of the transformer. Connects the core to either the input, in the case of the primary winding, or the output, in the case of the secondary winding.

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